COOLED DRINKING WATER[1]

By R. F. Massa

The existence of intimate relations between a proper drinking water supply and health is accepted, in a way, by all intelligent people. It is unfortunately true, however, that sanitary, like moral principles, are much more readily accepted as abstract truths than made a part of daily practice.

It is the writer's purpose in what follows to state the principles involved in supplying proper drinking water, and to describe the requirements of such a supply. It is his further purpose to make clear the importance of honoring these principles in the observance rather than in the breach. The material offered for consideration will be presented from the point of view, principally, of the factory manager, but the considerations which govern are essentially those touching the human rather than the purely mechanical element in manufacture, and they therefore have an essentially broad appeal and interest.

Suggestions have been taken from a number of articles that have appeared from time to time on this and allied subjects, as well as from experience, and the passage of time since these articles were consulted has so dimmed memory of the exact origin of many of the points that proper credit will be difficult if not impossible—

"An' what 'e thought 'e might require,
'E went an' took—the same as me!"

There are two essentially fundamental requirements in an efficient drinking water system. In working out such a supply, these two points govern: first, the water must be pure; second, it must be at a proper temperature.

The importance of purity of the supply has been recognized and has been generally insured. Various devices, operated by electricity and by steam, are provided and successfully operated for insuring a proper degree of purity. The final and equally vital problem has been much less successfully met. No matter how pure the water

[1] Read at meeting of Illinois Section, American Water Works Association, March 10, 1915.

may be, if its temperature is not right it will not serve its purpose. It will not be drunk. Further, no matter how pure the water supply may be, if it does not reach the user through means insuring that it has remained pure, a doubt is cast upon its purity amounting, in many cases, to practical certainty that it has been contaminated.

CORRECT TEMPERATURE FOR DRINKING WATER

The range of temperature at which water is palatable is rather narrow. Extensive experience has proven that there should not be a variation of over 5° as a maximum, from 50°. And yet, if one will apply a thermometer to the water supplied by ten drinking water fountains, it will be found in nine of the cases that the temperature is very far from this range.

There is a physiological basis for this preference for water at a temperature close to 50°. According to Dr. Thomas Darlington, secretary of the welfare committee of the American Iron and Steel Institute, water at this temperature stimulates the heart and also has some influence in relieving the internal temperature and equalizing it throughout the body.

ILLNESS FROM LOWER TEMPERATURES

On the other hand, water at a temperature appreciably lower than that named frequently produces cramps, or, if taken in quantities insufficient to produce this trouble in a clearly defined form, it lowers the efficiency of the individual affected, while leaving him in service. There is at the same time a further loss of efficiency in too little water having been consumed, and the whole value of the supply has therefore been destroyed. Water that is too cold is avoided as instinctively as water that is too warm. Tests to determine the influence of temperature upon the quantity consumed indicate a falling off of one-third with a fall in temperature from 50° F. to 40°.

STATEMENT OF SANITARY PROBLEMS INVOLVED IN PRODUCING A PERFECT SYSTEM

Having provided for the purity of the supply, the next question is how to get the water from the point where its purity is assured to the point at which it is to be consumed, with certainty that its purity has not been diminished, and further to deliver it at the palatable temperature.

Troubles from ice

One of the first difficulties encountered has been the problem of cooling. Water otherwise perfectly satisfactory for drinking has been contaminated by adding dirty ice or keeping it in a water cooler that has not received proper attention. This difficulty has in many cases, although unfortunately not in all, led to the use of receptacles in which the water is placed near the ice, or is in some way kept out of actual contact with it. Even though the ice is pure, it is generally handled in ways that are not conducive to cleanliness. Obviously, such ice should not come in contact with the water to be cooled, even aside from the question of temperature.

Futility of bottled waters

The second difficulty now develops: the problem of distribution. The purchase of waters for drinking has greatly increased during recent years, owing to the belief that by purchasing water in bottles or jugs there would be greater certainty of obtaining something that is entirely satisfactory. Some years ago, however, the Connecticut State Agricultural Experiment Station examined a considerable number of samples of such waters, and not only found a number that were not above suspicion, but pointed out that waters from uncontaminated sources might readily become unwholesome if carelessly marketed or bottled in unclean receptacles. The problem of proper cleansing of receptacles is by no means a simple matter.

The Bureau of Chemistry of the Agricultural Department at Washington has also reported an extended series of investigations which show that in many cases when the waters reach the consumer the bottles may not contain the water indicated by the labels, owing to incorrect labelling in the first place, or to tampering with the contents of the bottle on the way.

Even though the purity of the supply and the cleanliness of the method of handling the water are unquestioned, the use of drinking cups at the fountains invariably involves their use more or less in common, no matter what effort there may be toward the requirement of individual cups.

SANITARY SPECIFICATIONS FOR AN IDEAL SYSTEM

The ideal method of supplying drinking water whether in a public building, an apartment house, a hotel, a school or a factory, must aim,

First. At encouraging the use of a sufficient quantity by each person.

Second. The water must be made attractive.

Third. It must be carried from the point at which its purity is assured to the lips of the consumer in such a way as to insure its continuing pure.

Fourth. The drinking fountain should be white and clean in appearance.

Fifth. The water itself should be clear and sparkling.

Sixth. It should be placed convenient to the worker.

Seventh. Its temperature should be regulated and held constantly as close as possible to 50° F.

Quantity of water required per person

The quantity of water consumed by the average person amounts to about 3½ pints per day. Hot weather and exercise increase the demand.

The amount of water that must be supplied for each person in a drinking water system will vary through very wide limits, depending upon the design of the fountain. Usually where the design has been properly worked out the amount runs from one to two gallons per person per day. The larger figure is taken from the results in a large steel works. In schools the figure will often run as low as one-half gallon per person.

Results running up as high as 6 gallons per man and higher are occasionally encountered, but such figures seem invariably to go with defective fountain design or a water supply at a temperature above a palatable degree. Where the fountain is badly designed, there is often excessive waste because so small a portion of the water flowing can be drunk. Where the temperature of the supply is higher than it should be, the man will let the water run, to get it as cold as possible, and will otherwise waste it.

Economy of properly designed bubblers

Contrary to what one would expect, the consumption of water with a properly designed fountain is actually less per person than with drinking cups, where the temperature of the water and its attractiveness in other respects are the same. Tests made by Inspector Dougherty of the Water Department, Washington, D. C., showed definite economy by making the change from cups to bubblers. The reason for this is undoubtedly the effort to cleanse the public cup before it is used and the almost invariable drawing of a larger quantity of water than is consumed.

The design of bubbler fountains

It is obvious that in the design of the drinking fountains, the greatest care should be taken to produce the most efficient possible fountain jet, since the consumption of water varies through the widest limits, as above indicated, according to the efficiency or inefficiency of the jet.

Many of the older designs of fountains seem to have attempted to duplicate natural springs. Even when these fountains are fitted with self-closing valves so that no water flows except when the fountain is being used, only a very small percentage of the water that flows can be consumed. A design very much to be preferred as a matter of economy and of sanitary value is therefore that in which the water issues in the form of a jet. In fountains of this design, where the stream is allowed to rise to a point high enough so that there is no danger of the lips coming in contact with the fountain, the larger part of the water that flows can be drunk. A further advantage of the stronger stream is that it will flush off quickly any dirt that may have been carelessly or maliciously allowed to accumulate at the orifice. In some fountain designs, even this possibility is overcome by arranging a series of very small jets directed obliquely upward toward a common point at which the various jets impinge upon each other and the resultant stream is directed vertically. With this design, and, in fact, with any design, economy is sometimes attempted by cutting down the size of the stream in order to reduce the waste during the moment the man is drinking. This economy is readily carried to a point where it does more harm than good, because too small a stream will

not only waste a slight amount of time, but is very unsatisfactory to drink from.

It should not be necessary to point out the importance of having the shortest possible connections between the circulating system and the fountain so as to reduce the amount of water that may stand in the pipe and become warm. If this quantity of water is appreciable, the employees quickly get the habit of holding the fountain open long enough to insure that the "dead" pipe has emptied itself. Naturally, this means considerable waste of water and of cooling effect.

The importance of being able to keep the fountain and its surroundings thoroughly clean is also too obvious to call for special comment, and of course the design of the fountain as regards strength and appearance is a matter largely of its location, except that no matter how it is placed the appearance of cleanliness is vital.

CONSIDERATIONS OF COST AND OF VALUE

Cost of mechanical cooling versus ice

In the narrowest sense, the economy of a mechanically cooled drinking water system compared to the same system ice cooled, will also invariably work out in favor of the mechanical method, assuming that the equipment is at all suited to this method. But such a comparison is of little value, since the system of distributing the water is almost invariably changed at the same time that the method of cooling is altered, and there are too many factors to permit any one answer to cover all cases. In the New York office of one large company, the cost for this service was cut, by installing a machine and a better system of distribution, to about 25 per cent of the former cost. At the same time, the service was very much more satisfactory to the office force.

It cannot be too strongly emphasized, however, that considering economy and cost of operation where it involves mechanical cooling, or cost of ice, is merely considering the one least important item in the account and one that may well be sacrificed to other more important considerations.

Influence of improved conditions on employees

In the case of industrial plants, one large element involved in arranging a good system of supply is the effect on the employees'

feelings. Consideration for the comfort and well-being of the employees has a direct effect on their attitude to the plant. While in general, the character of the labor force determines to a certain extent the conditions in the place of work, while stenographers, to take an example, will not put up with the same lavatory facilities as factory girls, it is equally true that the conditions in the factory have a controlling effect on the character of the help that will seek employment.

Influence of proper equipment on efficiency

It is not often possible to get an accurate estimate of the improved efficiency following the installation of proper drinking water equipment, since the organization of the work in many shops is too elastic to bring out clearly the full effect. That effect is present, however, no matter how completely it may be hidden. In a rolling mill, one roller working at less than full efficiency lowers the capacity of the entire mill. Tonnage once lost is lost permanently.

In fact, in any industry where the work is arranged in a sequence of operations the effect of any falling off in the efficiency of the individual shows itself immediately. This prompt discovery of inefficiency, indeed, is one of the advantages of such an arrangement.

This arrangement of the work in a close sequence requires the holding of extra men ready to throw in at points needing reinforcement. This need of reinforcement appears very quickly where the operations follow each other closely, as, for instance, when the work moves along on a conveyor. This condition may be observed in the large packing houses. It may also be observed on the assembling floor of one of the large automobile companies. And in such work as this, the amount of extra work required is dependent on the general physical condition of the men, and is a measure of their condition.

As stated above, the difference between factories in which the organization brings out these defects in efficiency and those in which it does not bring them out, lies simply in the fact that in one case the defects are seen and in the other case they exist unseen.

The labor element in cost of production

In American factories, the labor cost is the big item. When one analyzes the prestige of American machinery, it will be found

to be due to the designs, to the tools and methods—in other words, to American engineering and also the higher grade of labor which is attracted by the better pay.

Within the shop the greatest pains are taken with the equipment. Steam engineers are provided to take care of the steam power, a building and repair department is provided for the factory and its general equipment, and a mechanical engineer and electrical engineer supervise the machines, machine tools and the electrical equipment. The one item, however, which is most expensive of all receives too little attention. The human mechanism, which after all is the most complicated mechanism in the organization, the most sensitive and by far the most responsive to proper treatment and proper conditions, is allowed to work under conditions which are given only the most casual care.

In the case of one of the larger companies that have investigated this matter thoroughly, there has been found a marked decrease in the number of absences in the summer time due to cramps, summer complaint, etc., since a properly designed system was installed, and at the present time practically all the cases of absences from work during the summer originate in one small and isolated section of the factory which it was not practical to provide with properly cooled water and which is still served by means of ice.

In a large rolling mill in the Pittsburgh district, there were formerly from two to five men overcome on practically every hot summer day before a modern system of cooling the water supply was installed. Since that time, this number of cases of heat prostration will be the toll of an entire season, and in the case of one recent season, one day, July 5, accounted for every case that occurred that year.

CONSIDERATIONS GOVERNING THE LAYOUT OF A COOLING SYSTEM

Cleanliness

The importance of absolute cleanliness in drinking water systems cannot be too strongly or too frequently emphasized. All surfaces with which the water comes in contact should be smooth and accessible for keeping clean without any particular effort, because the help usually available for such service is not of a type that will give any great amount of conscience to the work. Obstructions such as

pipe coils and supports should be designed with this in view. Proper facilities for flushing the tank should be provided to further assist in keeping things clean.

In many designs of cooling system, it is impossible to prevent the formation of ice and the consequent deposit of salts that are present in all natural waters and that are frozen out of solution as the ice is formed. The accumulation of these deposits and of organic matter that generally is present and that is also frozen out of solution, makes proper flushing especially important. Although such matter as may be present is presumably harmless in normal quantities, it is possible that in some cases it may prove dangerous in the increased quantity which its segregation by freezing brings about. And even though this material may be harmless in a given case, its appearance does not tend toward making the water attractive. The greatest care should therefore be taken in designing a system to avoid the formation of ice, so far as it is possible to do so. This is a matter generally left, of necessity, to the refrigerating engineer.

There are a number of arrangements in common use for cooling the water. In one system, the water is distributed uniformly along the top of a bank of coils containing the refrigerating medium and is allowed to trickle down over these coils and to collect in a tank below from which it is pumped to the distributing system. This arrangement has the advantage of comparatively ready access for cleaning, without the waste of any great amount of refrigerated water. Another arrangement frequently used is the immersion of refrigerating coils in a tank of the water. This arrangement is less desirable than that above mentioned, because of the probability of ice forming on parts of the coils. The circulation of the water over the cooling surfaces is likely to be sluggish in spots, and in fact, is practically certain to be, so that the ice will almost invariably form to a greater or lesser extent.

A third system that is in more or less use, is the one in which a drum or series of disks containing the refrigerant is revolved in the water to be cooled.

In all of these systems, there is more or less danger of contamination of the water by impurities getting in through ill-fitting covers, unless this matter is given proper consideration.

Reducing heat losses

The limitation upon the area that may be served economically from a single refrigerating unit has not been generally recognized because of the relative newness of the subject. It has been found in general, however, that the length and diameter of water distributing mains insulated with the best pipe covering known, should not exceed about 2000 feet of $1\frac{1}{2}$-inch pipe as a maximum, whether the main is arranged in a loop returning the water to the original point, to be re-cooled, or carries it to a second cooling station. This limitation is due to the heat losses into the pipe through the insulation, and power necessary to pump the water through the system fast enough to avoid too great a rise of temperature. Where longer mains are used, a result of failure to analyze the losses properly is that the temperature of the water will have to be too low to be used with safety at certain points, if its temperature is to continue low enough at the end of the loop to be palatable. The installation of such a system simply means that the expense of making it has been incurred and the real purpose of the work has been lost sight of.

In a recent installation in a large factory in central Ohio, the matter of length of mains was ignored, and the result was that the boiler and engine room force whose drinking fountains were supplied by water immediately after it had left the refrigerating machine, was compelled to drink water at so low a temperature—namely under 40°, that there was constant difficulty throughout the season from summer complaints of one kind and another.

It is, of course, impossible to draw the line between requirements calling for one and those calling for more than one machine without a study of local conditions, but, as the length of the circuit increases, the size of the mains to permit pumping the necessary quantity of water to avoid too great a range of temperature in the circuit increases rapidly, if the water is to be pumped without forcing the friction up above a proper limit, and with this increase the heat losses become excessive, while at the same time the cost of the installation is rapidly increased. In many cases the decreased cost of piping, due to the possibility of using smaller diameters of pipe and shorter circuits through which heat may enter the system, becomes a decisive factor in favor of installing more than one machine. Naturally, however, this matter is not of importance except in very large plants.

In laying out a drinking water system, there are obviously a number of factors which cannot be determined with any great degree of accuracy. It is important, therefore, that the capacity of the refrigerating unit shall be amply large to allow for the inevitable factor of ignorance in the laying out of the system and the further question as to whether it can be given skilled attention or not and whether this attention can be given frequently or only at considerable intervals, because in the latter case the capacity of the plant must necessarily be run at a lower point than where attention is more regular and more frequent.

A further matter calling for attention is that means must be provided to meet the requirements instantly when the period of heavy load comes on at the noon hour.

Further, the use of small units scattered at various points convenient to the more or less separated groups requiring fountains gives the system a flexibility as regards extensions that cannot be secured with the single central distributing plant. As additional buildings are constructed, the drinking water system corresponding may be added without interference with the existing system, whereas in a central system the mains are very likely to have been laid out of such size as not to permit their handling the large amount of water required without causing excessive friction.

Location of fountains

In laying out a system the approximate location of the fountains is, of course, determined by the requirements of the work. The number of fountains in a given location is determined by the number of people to be served. In general one fountain for every 100 persons to be served may be taken as a fair average, although the character of the work will affect this number, increasing or decreasing it as the case may be. In any case, the upper limit should be one fountain for every 200 persons.

If the fountains are placed too far apart, there is of course a loss of time going back and forth. No definite distance can be assigned. The distance must invariably depend upon local conditions.

One precaution is desirable in locating fountains; namely, to be sure that two fountains on different parts of the distributing system are not placed near together. Where there is even a very small

difference in the temperature of the water supplied, the people will always go to the cooler water even though the distance is considerably greater.

Insulation

The matter of proper insulation of drinking water piping is perhaps the most important item in arranging the piping system, except the design of the mains so that they may be short as possible.

Owing to the difficulty of placing the pipes in the ground in many cases and to the uncertainty regarding the dryness of the insulation where it is so placed, and therefore of its insulating value, the piping system is more often placed above the ground in passing from building to building. In any case, the heat losses through the insulation are generally the largest item to be taken care of by the refrigerating machine and too great emphasis, therefore, cannot be laid upon the importance of using the very best insulation possible.

There is a great mixture of motives that are effective at the present time in improving factory conditions. To the mind of one person, it is a matter of charity; to another, it is philanthropy and 5 per cent; to a third it is a question of what the law requires, and the law is requiring more and more all the time; to a fourth it is a realization that the prosperity and comfort of one man is bound up with the prosperity and comfort of every other—that we are dependent upon one another, and that, in a sense every man *is* his brother's keeper, even from the most selfish motive. However, whatever motive makes its appeal in any individual case, the fact remains that improved factory conditions are gradually coming more and more into consideration, and that conditions will continue to improve as a more intelligent understanding of their effect becomes general.